High Resolution Towed Body Surveys of Submesoscale Variability generated by Mean and Tidal Flows through the Lombok Strait

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LONG-TERM GOALS

To understand mixing processes and intensity within a complex archipelago and how well they can be inferred from satellites and numerical models.

OBJECTIVES

During the 2008 intensive measurements, we concentrated on three aspects of flow and mixing through the Philippine archipelago: flow separation around Apo Reef, flows forced by gap winds and winds around headlands, and water mass changes in the triple junction, or 'mixing bowl' between Mindoro and Panay Islands.

APPROACH

We operated two depth-cycling towed bodies, Triaxus and SWIMS3, to examine spatial and temporal variability of flow, water structure, and overturns for the three regimes studied. Turbulent dissipation rates and diapycnal diffusivities were then inferred by combining observed overturning scales with the stratification.

WORK COMPLETED

All data have been reduced and plotted. Scientific analysis has been limited because the 2008 and 2009 cruises used all funds, and we are waiting for analysis funding.

RESULTS

To consider one of our focus regions, the region south of Mindoro and west of Panay is a large 'mixing bowl' blending water from the South China Sea with that coming from the Pacific by two routes through the archipelago, one around the north end of Panay from San Bernadino Strait and the other coming south of Panay from Suriago Strait (Fig. 1). Ship tracks along or across sills bounding the mixing bowl were made with SWIMS3; other, longer and shallower sections were made with Triaxus

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across shoals bounding the deep region. Only one run was made across the southern entrance, 11, because SWIMS3 was snagged near the bottom at 500 m by a thick loop of line, probably part of a sunken Fish Attraction Device (FAD). The remaining ship time was consumed slowly working the towed body back to the surface and sawing through the line.

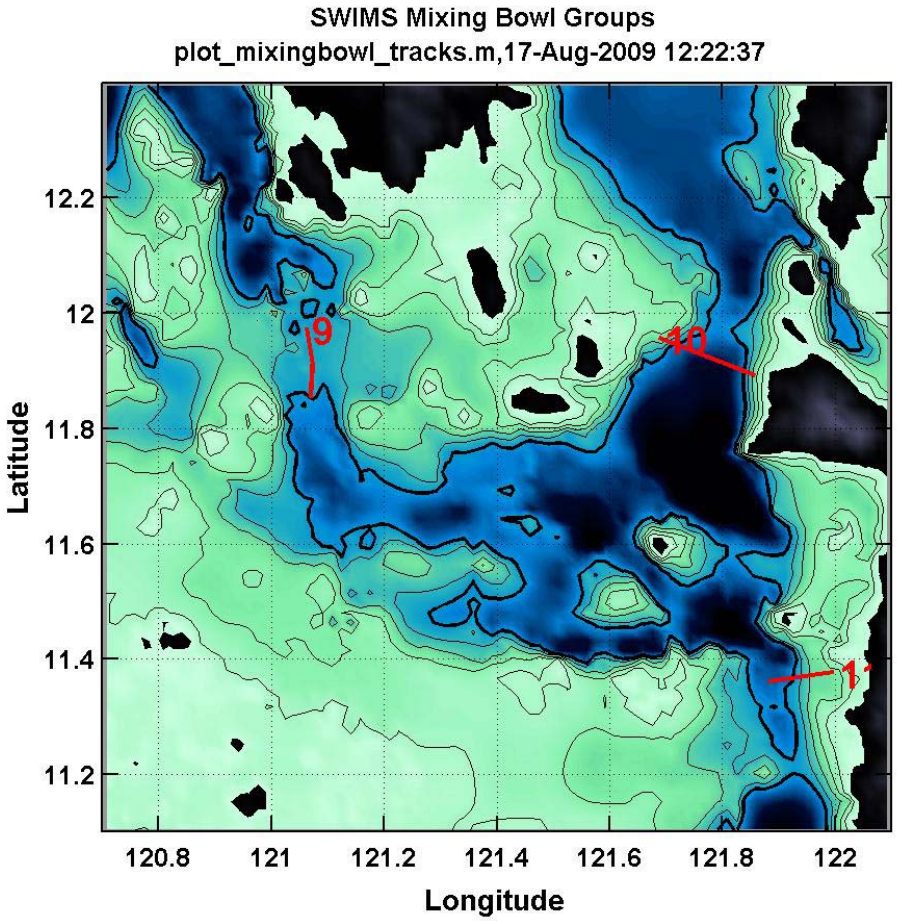

Fig. 1. Bathymetry and SWIMS3 tracks across entrances to the 'mixing bowl' the depression south of Mindoro and west of Panay. The numbers are SWIMS data groups, 9, 10, and 11. Flow across the north, 10, and south, 11, entrances connects to the Pacific with paths through the archipelago from San Bernadino and Surigao Straits.

Comparing average TS relations at the three entrances to the mixing bowl suggests significant mixing for water shallower than 250 m (Fig. 2). Water less dense than 24.5 coming from the Pacific appears to be mixed to produce the water over the eastern sill, linking the mixing bowl with the South China Sea. The water below that is consistent with mixing between eastern and southern entrances producing water at the northern entrance.

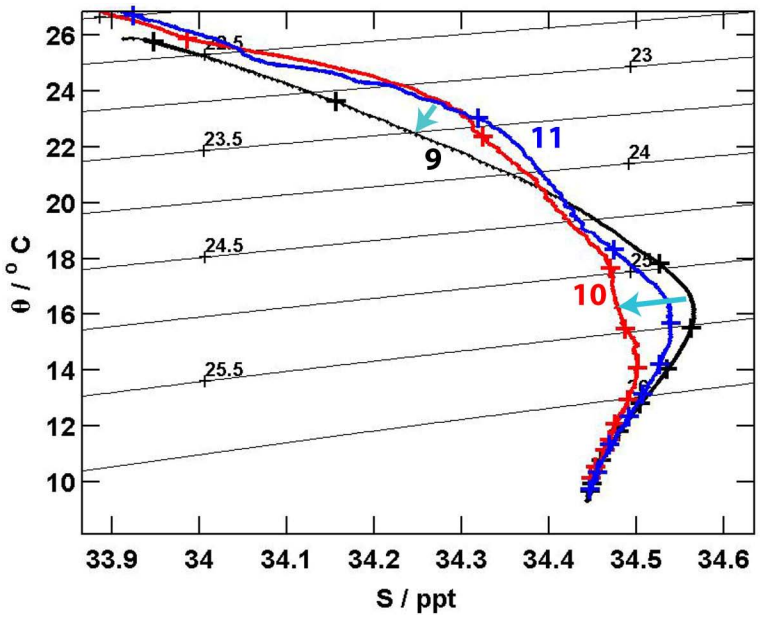

Fig. 2. Average TS relations at east (9), north (10), and south (11) entrances to the mixing bowl. Plus signs are at 50 m intervals. Water coming from San Bernadino and Suriago Straits with density between 22.5 and 24.5 is mixed to produce the water found over the sill at the north end of the mixing bowl. Water from south and east entrances between 24.5 and 26 appears to be mixed to produce water at the north entrance.

From minimum diapycnal diffusivities of 10^{-5} to 10^{-4} m^2 s^{-1} just below the surface mixed layer, mixing rates increased with depth, reaching maximum of 10^{-3} m^2 s^{-1} close to the bottom, which lacked prominent homogenous boundary layers.

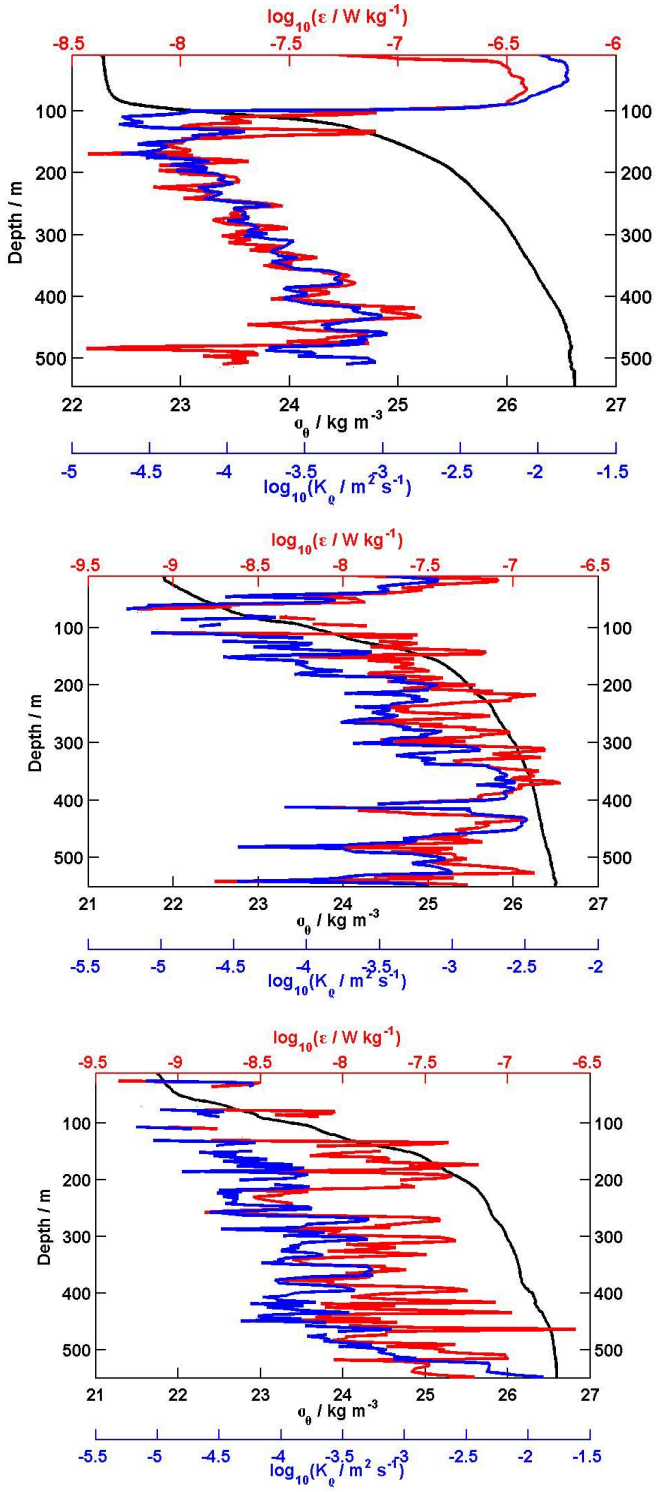

Fig. 3. Average density and mixing rates inferred from overturns in individual density profiles, for SWIMS3 groups 9, 10, and 11, from top to bottom.

IMPACT/APPLICATIONS

Mixing rates presented above will be used to constrain diapycnal diffusivities in numerical models of flow through the archipelago. Other results, not shown here, are being compared to model simulations of gap winds, to test the models and to understand the influence of these winds on circulation within the island group.

RELATED PROJECTS

Most of the other PHILEX projects are related to this work, particularly those of Arnold Gordon, Matthew Alford, James Girton, Pat Gallagher, and Julie Pullen. In addition, observations in the Aegean provide a contrast with a more open archipelago.